Comparison of EHC®, EOS®, and Solid Potassium Permanganate Pilot Studies

URS

1. PROBLEM: TCE ~1,000 µg/L IN FINE-GRAINED SOILS

2. OBJECTIVES

Conduct three pilot studies to compare:

- The effectiveness of both reducing and oxidizing amendments to reduce trichloroethene (TCE) concentrations in groundwater, and
- The amendment distribution by two different delivery methodologies into fine-grained soils

3. PILOT STUDY ACTIVITIES

Three pilot studies were conducted in saturated fine-grained soils:

- Emplacing the chemical- and biological-reducing reagent (EHC®) by hydraulic fracturing,
- Injecting emulsified vegetable oil (EOS) via injection wells (gravity feed), and
- Emplacing solid potassium permanganate ($KMnO_4$) by hydraulic fracturing.

4. AMENDMENT COMPARISON

	EHC®	EOS®	POTASSIUM PERMANGANATE
PRODUCT DESCRIPTION	Fibrous organic material and zero valent iron (ZVI)	Emulsified vegetable oil	Solid $KMnO_4$
DESTRUCTION MECHANISM	Biotic and abiotic (chemical) reductive dechlorination	Biotic reductive dechlorination	Chemical oxidation
TCE DESTRUCTION	1,000 → <5 µg/L	>200 → <5 µg/L	>1,000 → <5 µg/L
TREATMENT TIME	• 24 months for TCE • >24 months for cis-1,2-DCE	• 3-6 months for TCE • 12-28 months for cis-1,2-DCE	<6 months (date of first post-fracture sampling event)
FORMATION OF TCE DEGRADATION BYPRODUCTS	Yes	Yes	No
REBOUND	Yes	Yes	No
AMENDMENT LONGEVITY (REACTIVITY)	12 to >24 months	<12 to 28 months	At least 12 months
DISTRIBUTION AFTER INJECTION	5 feet horizontally in 12 months	5 feet horizontally in 12 months	• 5 feet horizontally in 12 months • 5-15 inches/month vertically (in first 6 months)
SECONDARY WATER QUALITY CHANGES	• Increased calcium, potassium, sodium, magnesium, arsenic, barium, boron, iron, manganese, strontium, TDS	• Increased arsenic, iron, manganese, TDS • Decreased pH	• Increased barium, chromium, manganese, TDS • Decreased arsenic and cadmium • Did not increase Cr VI
AMENDMENT COST PER CUBIC YARD	$13.5 (sands or fines)	$5.5 sands, $8 fines	$10 (sands or fines)

5. DELIVERY METHOD COMPARISON

	INJECTION WELLS	HYDRAULIC FRACTURING
EXTENT OF DELIVERY	5-8 feet	6.5-12.5 feet
DISTRIBUTION	• Non-uniform • Distributed in more coarse-grained soils	• Non-uniform • Surfacing (short circuiting) potential • Distributed in *both* fine- and coarse-grained soils
TIME TO INJECT (1 Location, 10-foot Radius, 25-foot Vertical Zone)	• 2 days if manifold system is used	• 1 day - no surfacing • 4 days - 3 surfacing events and drill rod breakage
PILOT STUDY COST (Amendment emplacement only. No oversight cost.)	$50K (single injection event)	$70-100K

6. LESSONS LEARNED

- Expect non-uniform horizontal and vertical distribution of amendments using either injection wells or hydraulic fracturing
- Have a monitoring period of at least 24 months to determine full results
- Expect secondary water quality parameter changes to last years
- Consider using bentonite in lieu of polymer for hydraulic fracturing

7. CONCLUSIONS

1. All three amendments:
   a. Decreased TCE to below 5 µg/L (cleanup standard)
   b. Continued to distribute after injection
   c. Increased metals and TDS concentrations

2. $KMnO_4$ was selected as the preferred amendment for the Defense Distribution Depot San Joaquin - Sharpe site since it:
   a. Distributed/diffused more than other two amendments.
   b. Destroyed TCE quicker without degradation byproducts.

3. Both distribution technologies resulted in non-uniform distribution.

4. Hydraulic fracturing increased distribution in fine-grained soils.

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